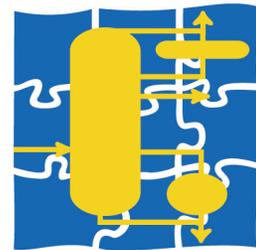


1.3 Introduction to CAPE-OPEN and CO-LaN

Bertrand Braunschweig
IFP & CO-LaN



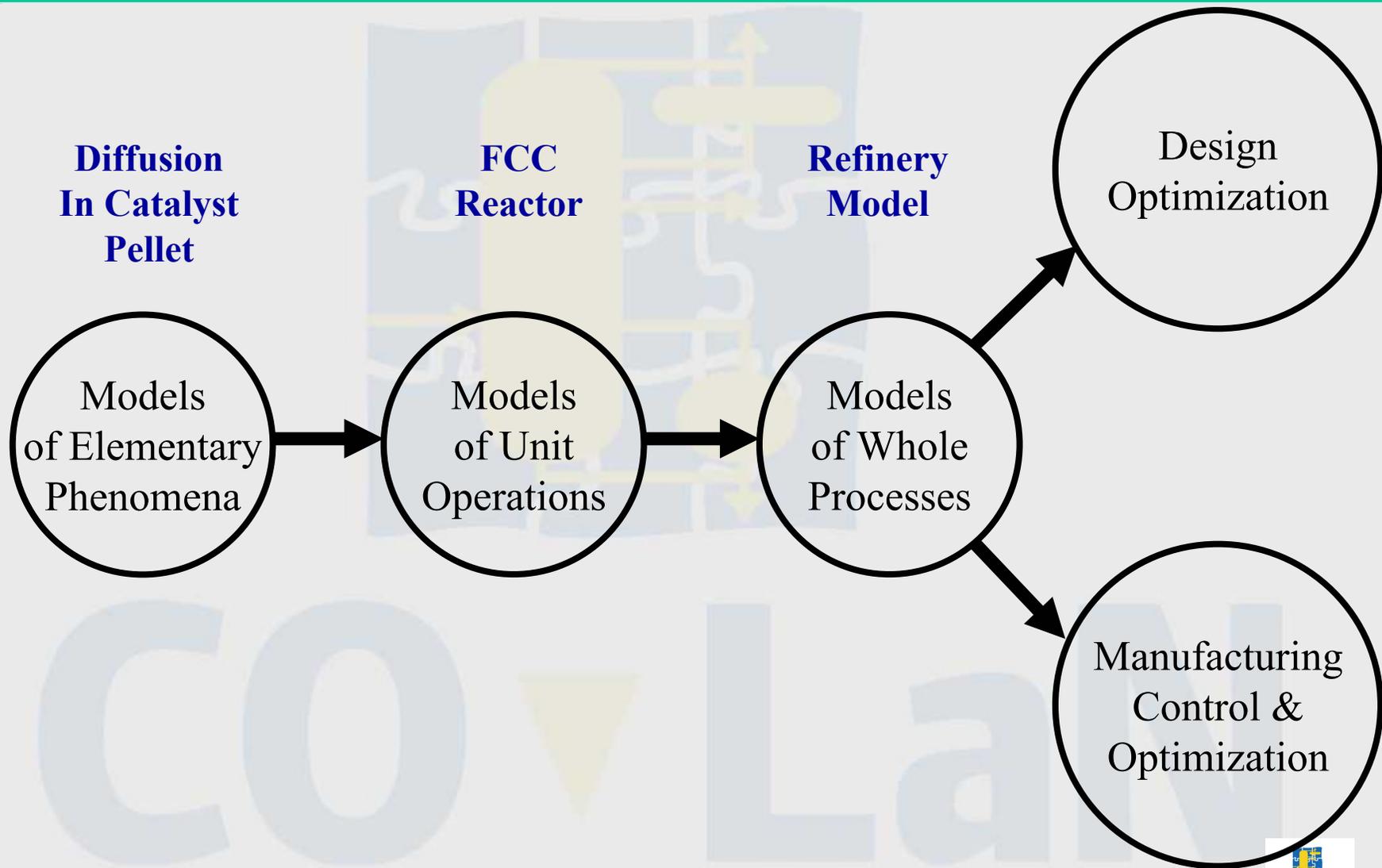
CO ▼ LaN



CAPE

- ▼ **Acronym for Computer Aided Process Engineering**
- ▼ **Encompasses the building of process models to increase understanding, and the use of these models to design and operate process plants**

CAPE application range



CAPE

- ▼ **CAPE techniques were first used in the 60s and 70s in the largest oil and chemical companies**
- ▼ **In the 80s, these companies generally had their own in-house simulation programs and resources**
 - ⇒ **e.g. Monsanto: Flowtran, BP: Genesis...**
- ▼ **In the 90s, almost all abandoned their in-house tools in favour of third-party (commercial) programs**
 - ⇒ **Aspen Plus, PRO/II, HYSYS, gPROMS...**
- ▼ **There is a strong need to integrate in-house models in these commercial environments**

CAPE-OPEN Vision

CAPE-OPEN
COMPLIANT SOFTWARE

UNITS'Я'US®

α-olefins reactor v12.3

B2B ready

Tested

As seen on the Web!

PLUGS
INTO ANY
COSE

Peter Banks sold... (52)
055)October 1998... (ANT. Message Suite is not com...
a version of EasyFax... Series 5you must remove this BEFC...
"What to do if you have... 4" for instructions.The Message S...
to the Series 5Control Panel... (ns). You must change setting... in the... man...
program before you can use the M... rams. See the Message Suite U... id... ion...
have a previous version of Message S... It...
is best to install the new release without... previousversion so that your settings (e.g. email messages...
setup and serviceprovider information) are p... se settings will be removed ifyou remove your existing...
version before upgrading.Note that it is recomm... that you back up your Series 5 beforeinstalling additional

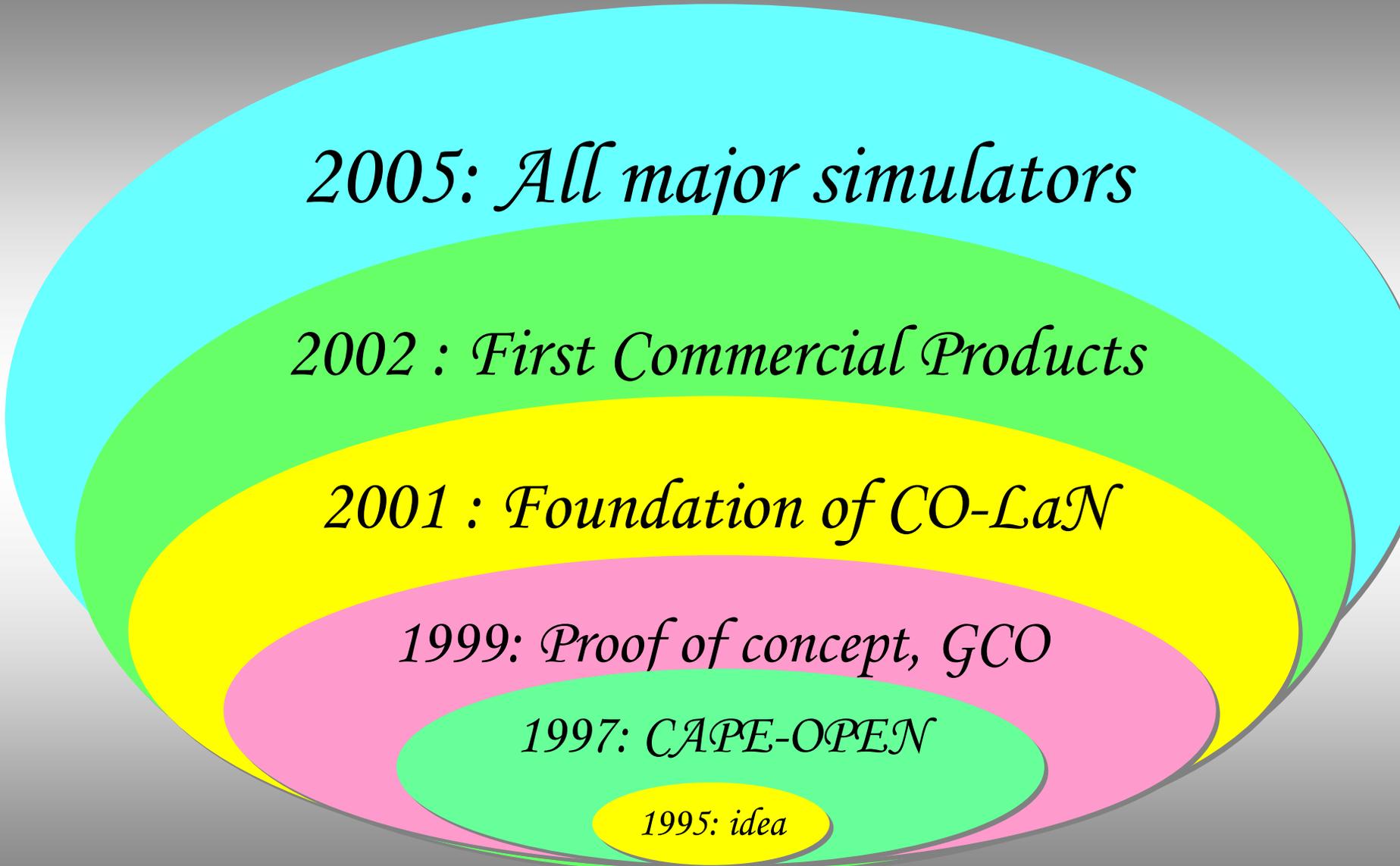


CAPE-OPEN

Industry Standard
for Process Modelling Software Interoperability

CO  LaN





2005: All major simulators

2002 : First Commercial Products

2001 : Foundation of CO-LaN

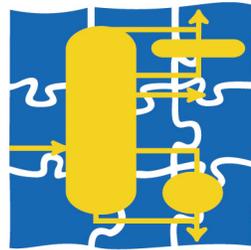
1999: Proof of concept, GCO

1997: CAPE-OPEN

1995: idea

The CAPE-OPEN Standard

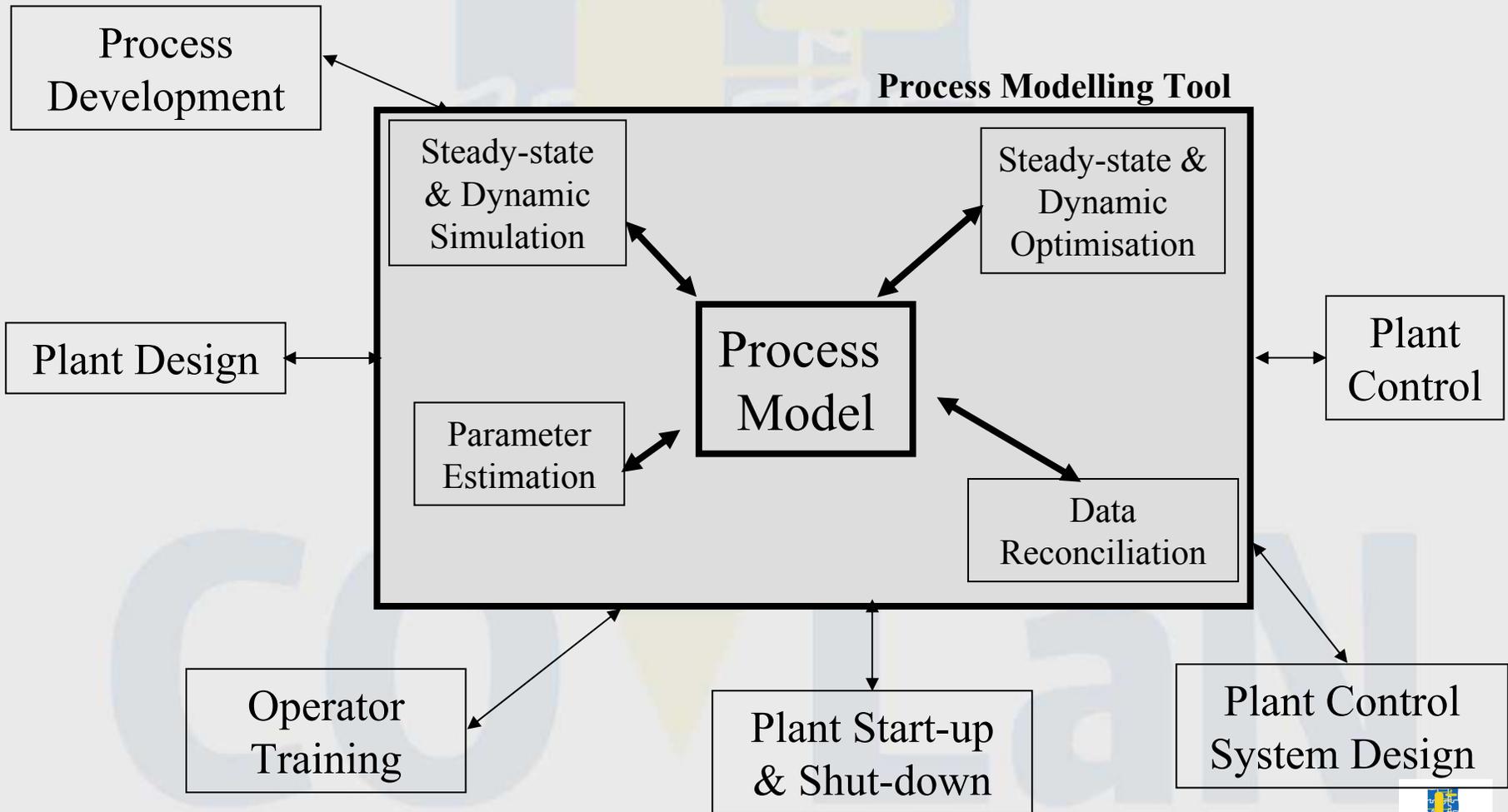
What it is



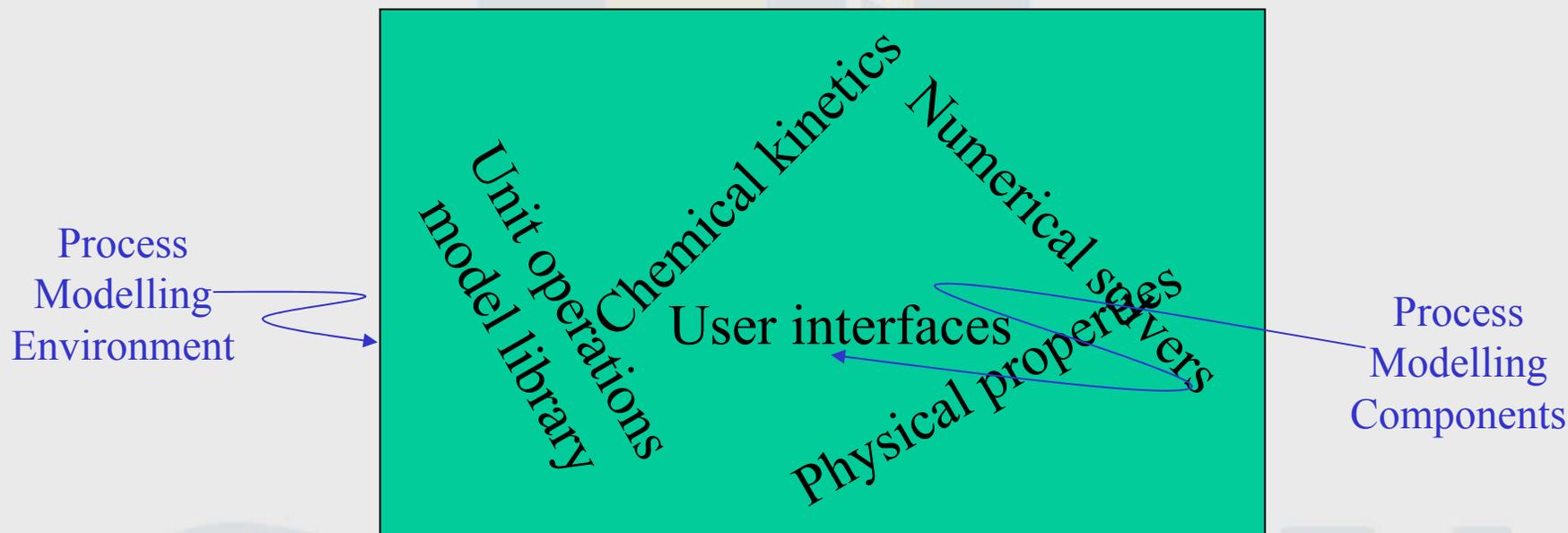
CO ▼ LaN



General-purpose process modelling tools



The anatomy of process modelling tools – a (somewhat) confusing reality



- Many interacting components...
- ...all tightly coupled with each other
- Component boundaries not always clearly delineated

Process modelling: components & environments

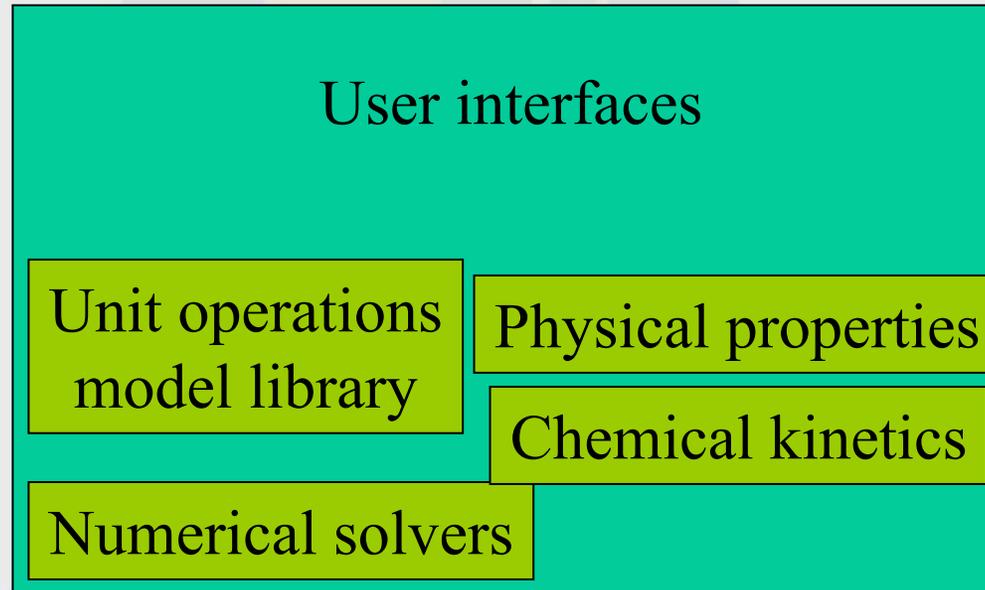
▼ Process Modelling Components (PMCs)

- ⇒ well-defined pieces of software, relatively narrow function
- ⇒ wide range of applications
 - physical properties
 - unit operation modules
 - numerical solvers
 -

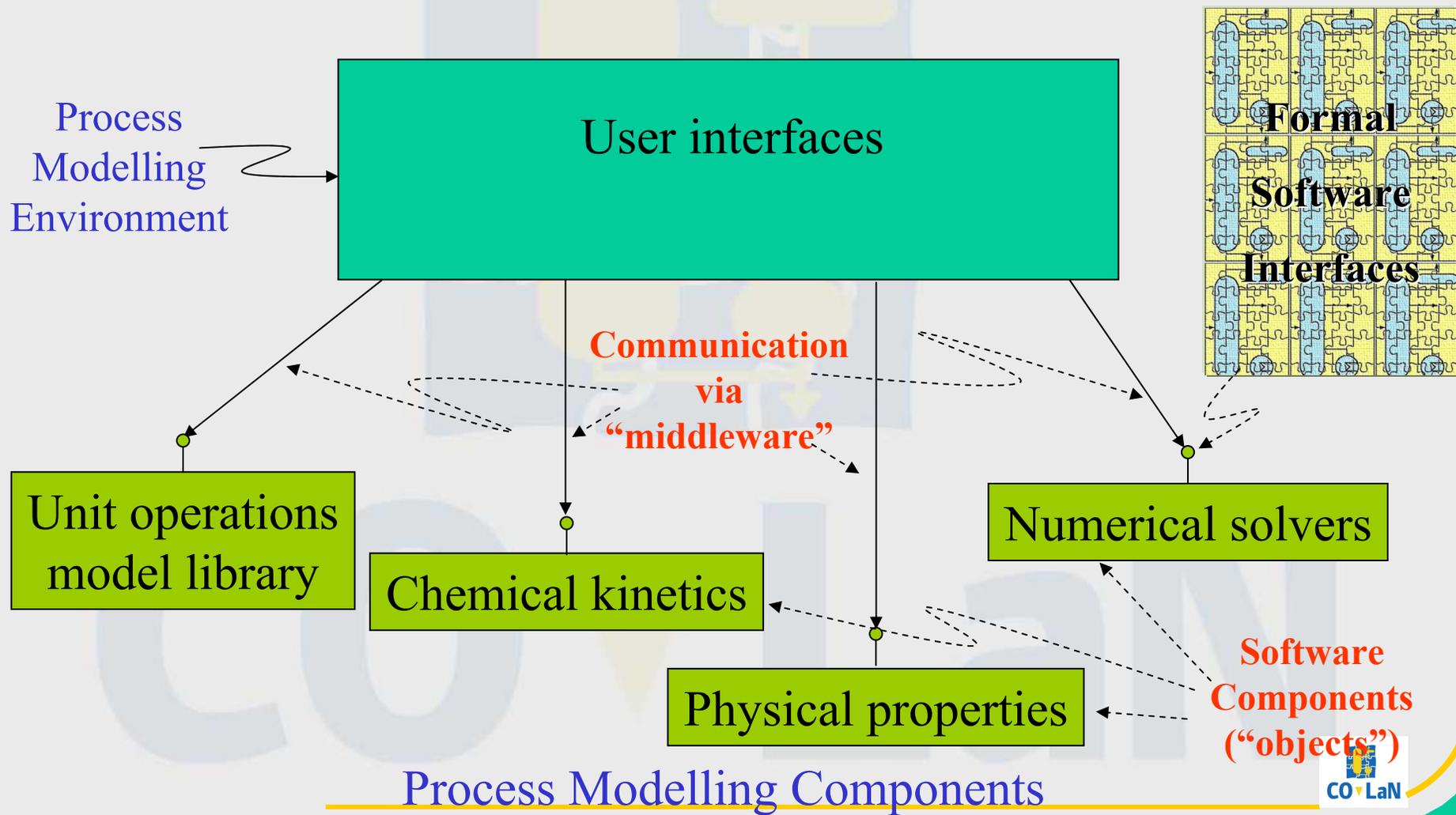
Process modelling: components & environments

- ▼ **Process Modelling Components (PMCs)**
- ▼ **Process Modelling Environments (PMEs)**
 - ⇒ **support construction of process model**
 - **from first-principles and/or library of unit operation models**
 - ⇒ **support a number of model-based applications**
 - **simulation, optimisation, ...**
 - ⇒ **may make use of one or more PMCs**

Clarify boundaries between key components



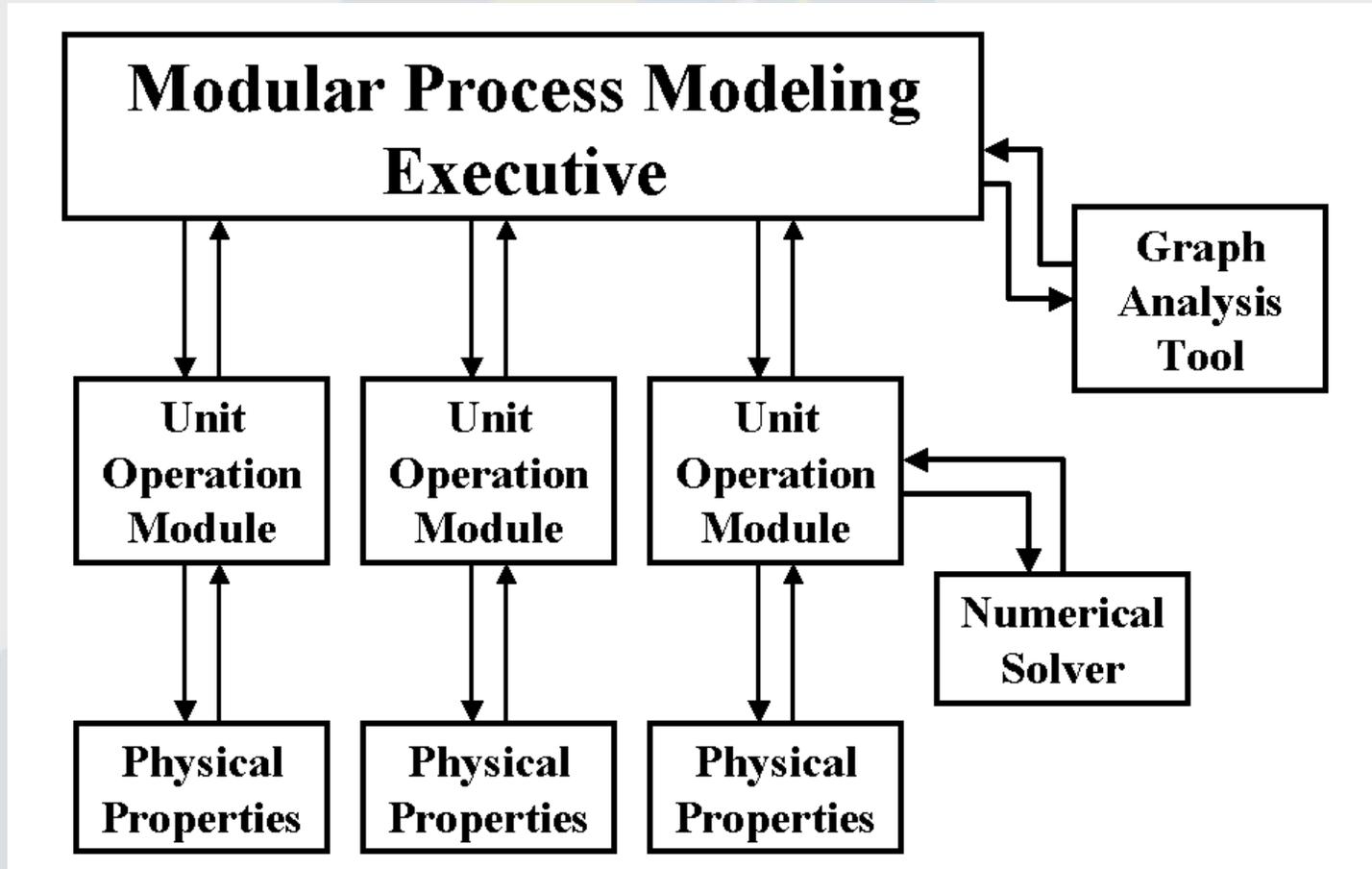
...and break tool into 1 PME & multiple PMCs



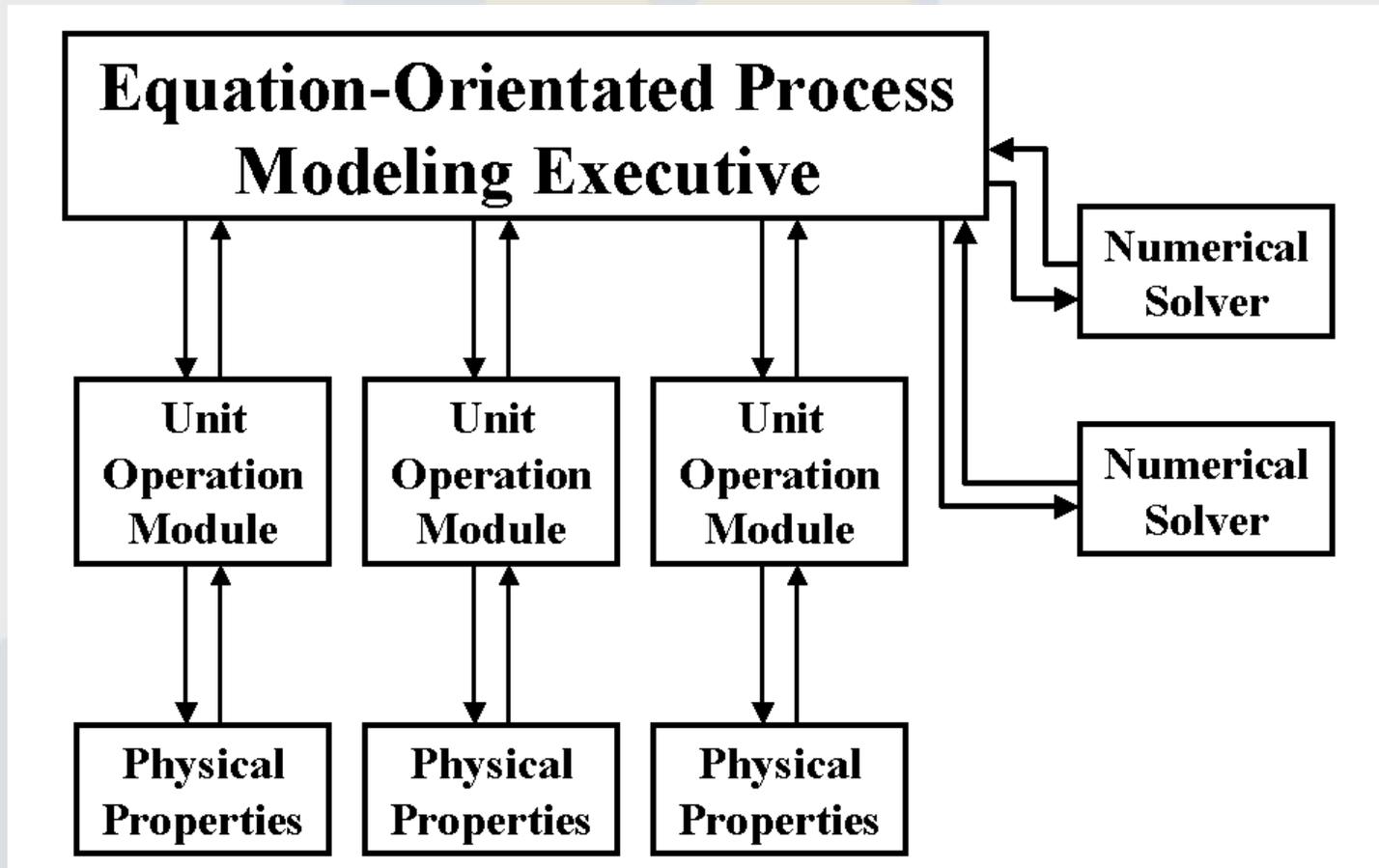
CAPE-OPEN interface specifications

- ▼ list of interfaces/Methods/Arguments together with documentation and IDL code
- ▼ Allowing to develop *plugs* and *sockets* in PMCs and PMEs
- ▼ Published on the internet by CO-LaN
- ▼ Free to use by anyone

Typical modular process modelling tool



Typical Equation-Orientated process modelling tool



CAPE-OPEN architecture

▼ Business interfaces

- These interfaces are domain-specific interfaces for the CAPE application domain. They define interfaces to CO components involved in a CO process simulation application.

▼ COSE/PME Interfaces

- They are interfaces for CO simulator executives. Within this category, services of general use are defined such as diagnostics and material systems in order to be called by any CO component.

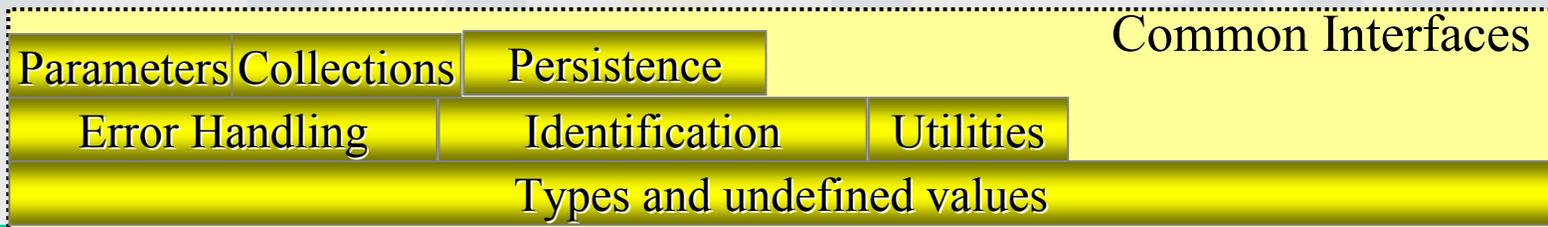
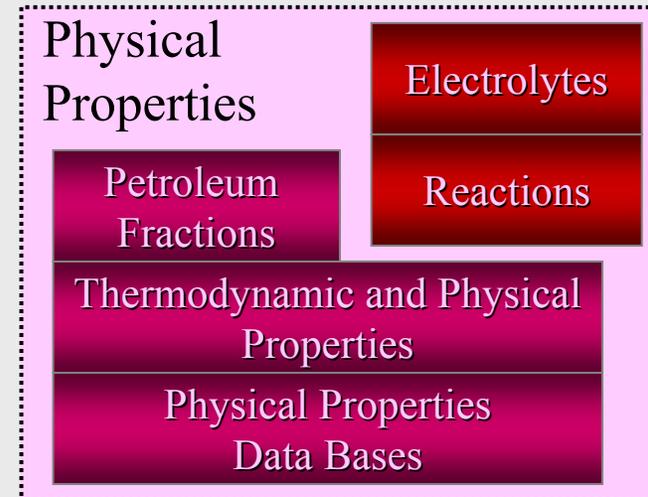
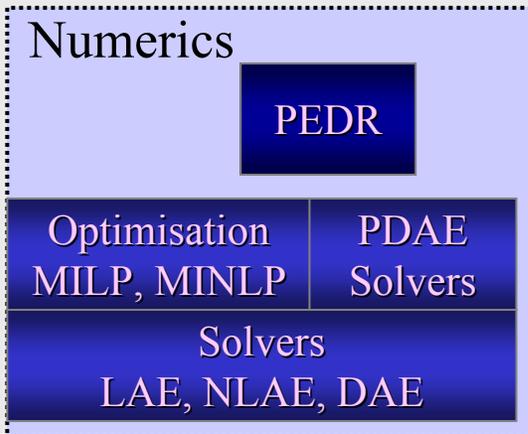
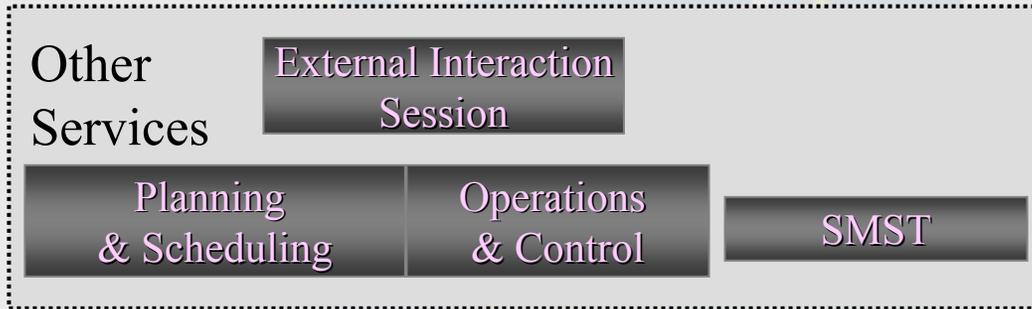
▼ Common interfaces

- specifications for handling services that may be required by any Business and COSE/PME interfaces. They support basic functions and are always independent of Business and COSE/PME Interfaces.

CAPE-OPEN Implementation

- ▼ **Object-oriented approach based on software components**
- ▼ **Extensive use of “middleware”**
 - ⇒ **CORBA - Object Management Group's Interface Definition Language**
 - ⇒ **COM - Microsoft's Component Object Model Interface Definition Language**

CO Interfaces for PMCs



CO interfaces releases

0.9 (CAPE-OPEN)

0.93 (GCO 2001)

1.0 (GCO 2002)

Unpublished drafts

New releases in 2005

Other
Services

External Interaction
Session

COSE/PME Services

Planning
& Scheduling

Operations
& Control

SMST

Numerics

PEDR

Hybrid Solvers

Optimisation
MILP, MINLP

PDAE
Solvers

Solvers
LAE, NLAE, DAE

Hybrid Units

Dynamic Units

Unit Operations

Physical
Properties

Electrolytes

Reactions

Petroleum
Fractions

Polymers

Thermodynamic and Physical
Properties 1.1

Physical Properties
Data Bases

Parameters

Collections

Persistence

Common Interfaces

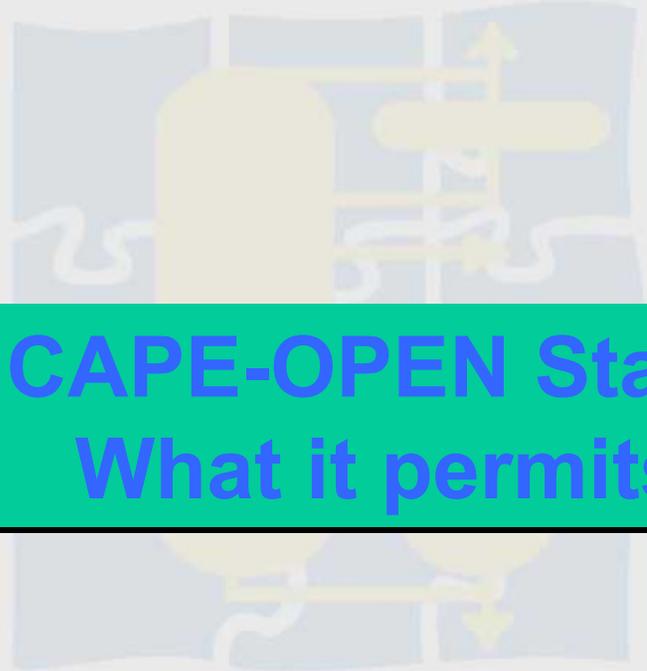
Error Handling

Identification

Utilities

Types and undefined values





The CAPE-OPEN Standard: What it permits

CO  LaN



Direct Benefits

Cheaper, better and faster design, operation and control of processes

⇒ Plug-and-play :

- Ability to seamlessly integrate a component from the library of foreign objects (unit operations, thermo models, solvers etc.);
- Ability to seamlessly integrate in-house proprietary components in commercial environments;

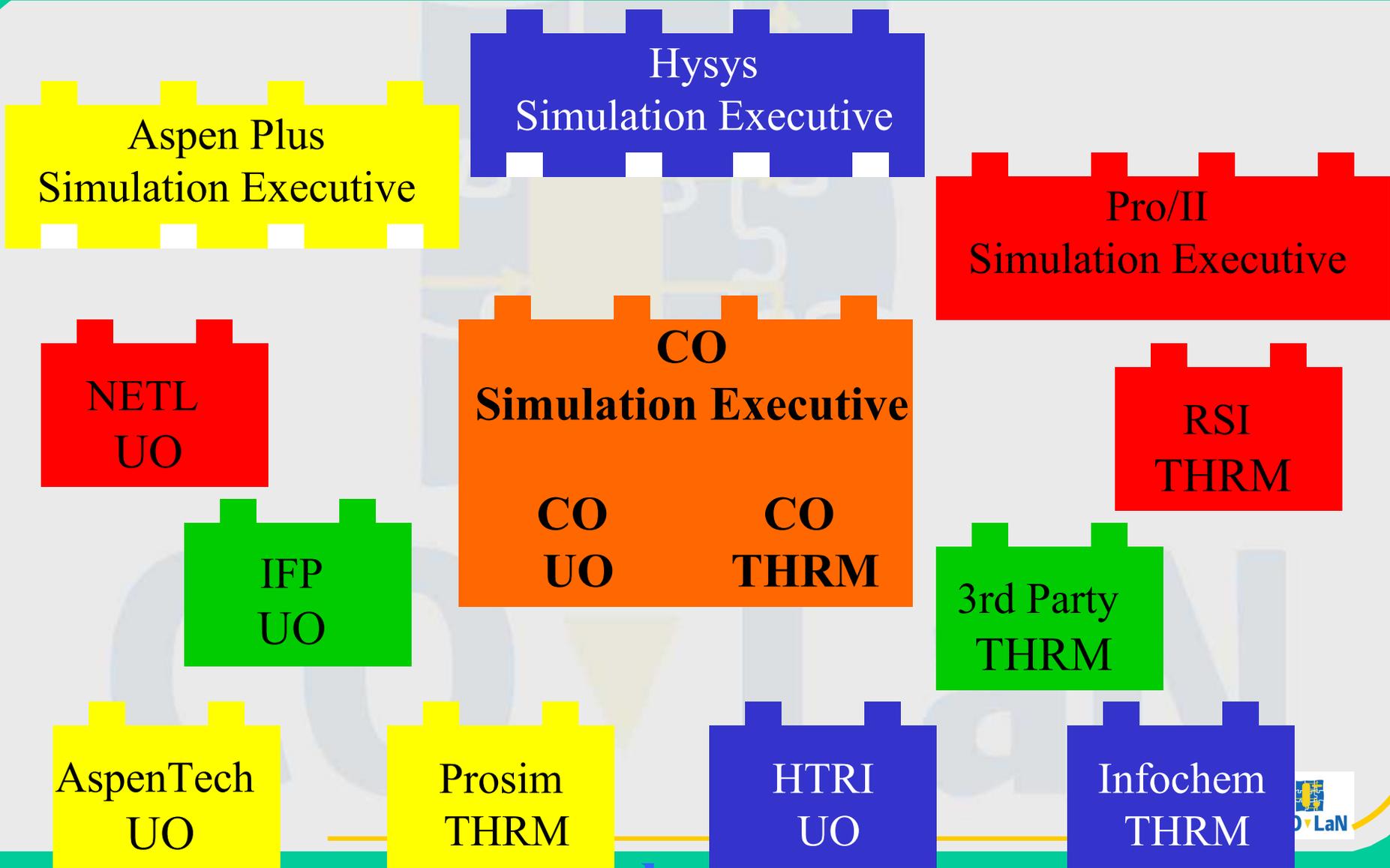
⇒ Niche software

- Ability to link specific niche modules to the simulators. Small and niche software vendors will provide CO-compliant components.

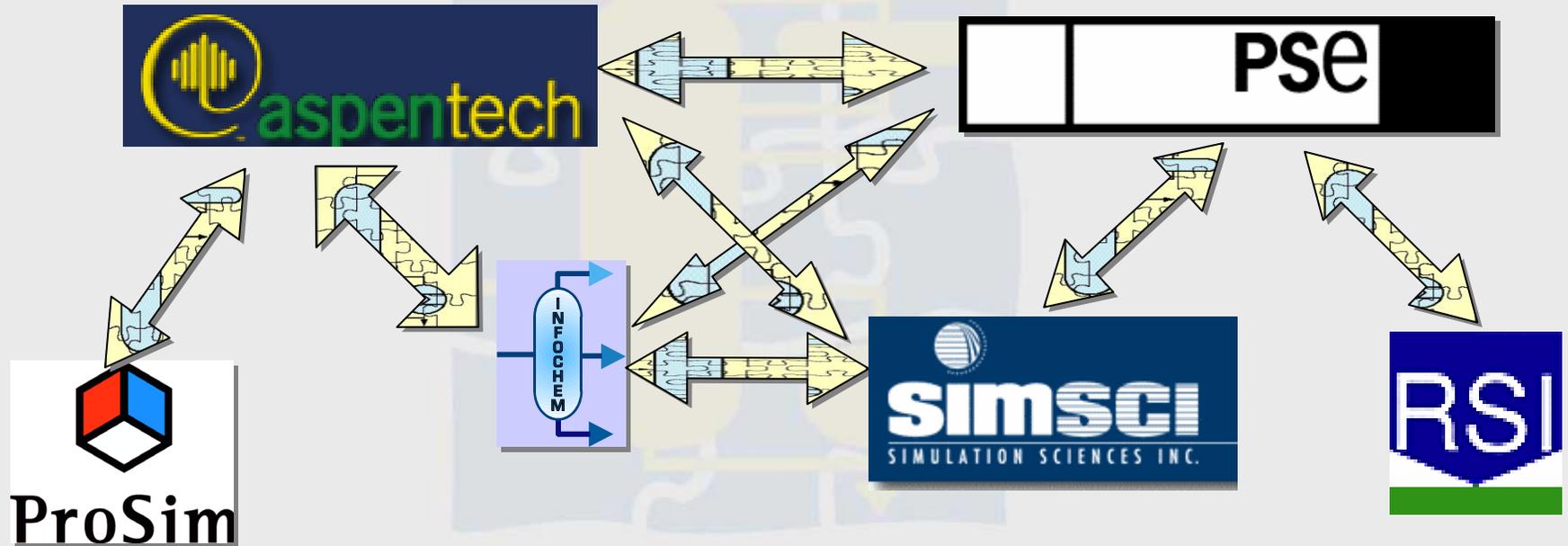
⇒ ROI

- Individual studies will cost less because of the technical advantages of being able to mix-and-match.
- Plug-and-play capacity will stimulate the market and create new opportunities

CAPE-OPEN supports all combinations of components



Commercial Interoperability of Unit and Thermo



- ▼ Many combinations tested (not all)
- ▼ As well with some operating companies legacy software
- ▼ Almost no performance degradation in best case

Example of use 1

- ▼ **A physical and thermodynamic properties calculations PMC developed by a supplier, can be used the same way within several CO-PMEs.**
- ▼ e.g. Infochem's , Multiflash, can be used the same way in Aspen+, gPROMS, Hysys, Pro/II.
- ▼ The user saves the time needed to configure the properties calculations parameters for those environments, and gets consistent results by using the same methods and data.
- ▼ This is simply obtained by wrapping the thermo server with CAPE-OPEN standard interfaces.

Example of use 2

- ▼ **A Unit Operation model** such as a proprietary chemical reactor model, developed by an operator or a process licensor, **can be used transparently in CO-compliant PME**s.
- ▼ e.g. IFP 's FIBER (FIxed BEd Reactor) generic reactor model can be used the same way in most commercial PMEs without any change, without any coding or compiling.
- ▼ The process licensor can easily serve clients who demand the use of a specific PME in their contracts.
- ▼ This is obtained from putting the reactor model to the Unit Operation standard: introduction in a flowsheet, connection of input-output ports, specification of parameters, validity checking, calculation, publication of results.

Available CO-compliant software

▼ Software providers

- ⇒ AspenPlus, AspenProperties
- ⇒ Hysys, COM Thermo, Distil
- ⇒ SimSci: Pro/II
- ⇒ PSE: gPROMS
- ⇒ Belsim, Infochem, ProSim, RSI, HTRI, Fluent, Chemsep, PPDS...

▼ Operating companies

- ⇒ IFP, Total, BASF, Norsk Hydro, Shell...

▼ Governmental

- ⇒ US EPA, NETL

▼ Universities

- ⇒ DTU, INPT, UPC, RWTH.LPT, CMU, TUHH...

▼ CO-LaN





The CO-LaN

CO ▼ LaN



CO-LaN

- ▼ **Non for profit organisation**
- ▼ **Full members (paying fees): CAPE end-users**
 - ⇒ Air Liquide
 - ⇒ BASF
 - ⇒ BP
 - ⇒ Dow (current chair)
 - ⇒ IFP
 - ⇒ Shell
 - ⇒ Total
- ▼ **Associate members: all the other CAPE players (around 40 and increasing)**

CO-LaN Membership as of May, 2005



- 22 Software suppliers
- ◆ 7 Operating Companies
- ▲ 2 Governmental
- 11 Universities
- ★ 4 Individuals



1. User priorities for CAPE-OPEN standard:

- ▼ **work with software vendors to communicate user priorities for process modelling software component/environment interoperability**
- ▼ **promote communication and co-operation among CAPE software vendors to insure that the CAPE-OPEN standard actually translates into commercially valuable interoperability**
- ▼ **Activities**
 - ⊖ **Roadmap building**
 - ⊖ **Consultancy Scheme**
 - ⊖ **All links with software vendors**

2. Exploitation and dissemination:

- ▼ promote the CAPE-OPEN standard to end-users and distribute CAPE-OPEN information and technology internationally
- ▼ **Activities**
 - ⇒ Website (www.colan.org)
 - ⇒ CAPE-OPEN Update newsletter
 - ⇒ Conference participations
 - ⇒ Workshops such as this one
 - ⇒ etc.

3. CAPE-OPEN specifications life cycle management

- ▼ organise the maintenance, evolution, and expansion of the specifications following user priorities
- ▼ Activities:
 - ⇒ SIGs (as of May 2005):
 - Thermo SIG
 - Unit SIG
 - Interoperability SIG
 - ⇒ Other actions on specifications
 - polishing, publishing,...

4. Testing, interoperability facilitation

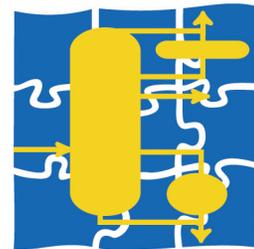
- ▼ **supply compliance testers to support development of components**
- ▼ **organise interoperability tests between suppliers of Process Modelling Components and Process Modelling Environments**
- ▼ **Activities**
 - ⇒ **The CO Tester suite**
 - ⇒ **The CO Laptop(s)**
 - ⇒ **Interoperability workshops**

5. Training/Migration facilitation

- ▼ ensure that training modules guidelines and tools to facilitate component wrapping are developed and available
- ▼ **Activities:**
 - ⇒ Migration wizards
 - ⇒ Presentation material & guidelines
 - ⇒ No formal training activity yet

Introduction to CAPE-OPEN & CO-LaN

Bertrand Braunschweig
IFP & CO-LaN



CO ▼ LaN

